Potential permafrost distribution in Central Yakutia based on microwave remote sensing data

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Abstract

Permafrost extent is an important input variable for climate modelling. Current methods to derive permafrost extent from satellite measurements utilize coarse resolution scatterometer data. In this study we examine the possibility of improving permafrost mapping through additional information obtained from higher resolution SAR measurements. We focus on the region of Central Yakutia as it has shown to be a problematic region for mapping of potential permafrost distributions in the past.

Keywords: Scatterometer; SAR; permafrost extent; surface state

Introduction

Knowledge about permafrost extent is a critical part of climate modelling and prediction (Cheng & Wu, 2007). Different strategies to obtain a dataset suitable for the determination of the extent of permafrost based on degree days have been proposed (e.g. André et al., 2015; Gruber, 2012, Westermann et al., 2015). Interpolation, especially use of reanalysis data is essential in all cases. Purely satellite observation based methods can only account for frozen or unfrozen days (Park et al. 2016) but can be translated into potential mean annual ground temperatures (Kroisleitner et al. 2017). The accuracy differs between the microwave sensors due to resolution (25km vs 50km) and frequency (ASCAT 5.7cm, SSM/I 0.8cm). Kroisleitner et al. (2017) found Central Yakutia to be a region of high disagreement for permafrost extent between results excluding and including days of snow melt. This area also showed comparatively low performances of the empirical mean annual ground temperature (MAGT) model (Kroisleitner et al., 2017). In this study we focus on the area of Central Yakutia and compare the results of Kroisleitner et al. (2017) with freeze/thaw data based on a higher spatial resolution experimental dataset from Synthetic Aperture Radar (SAR) data (Sabel et al., 2012) to quantify the effect a higher spatial resolution has on the end results.

Data and Methods

Ground temperature data

The in situ data used in this study was obtained from the Global Terrestrial Network for Permafrost Database (GTN- P).

Surface State data

We used two radar data sets with differing spatial and temporal resolutions. The first data set was obtained from the Advanced Scatterometer (ASCAT) instrument on the MetOp satellites and is provided in a 12.5km grid (Paulik et al., 2014). The second data set was obtained from the Advanced Synthetic Aperture Radar (ASAR) instrument on the Envisat satellite and is gridded to 0.5km (Sabel et al., 2012). Both instruments operate at C-band.

Methodology

The thresholds and empirical relationships between frozen days and temperature proposed by Kroisleitner et al. (2017) are applied to the ASAR freeze/thaw data set. The results are compared and analyzed for differences concerning landscape and soil texture.

Results

The higher spatial resolution leads partially to higher performances compared to results of Kroisleitner et al.

(2017) but varies with respect to land cover which impacts thaw detection performance with SAR records.

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